Prepared for:

Chino Mines Company

Hurley, New Mexico

REVISED DRAFT

Administrative Order on Consent

Interim Remedial Action
Groundhog Mine Stockpile
Site Investigation Report
Hanover and Whitewater Creeks Investigation Unit

Prepared by:

Golder Associates

Tucson, Arizona

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1. INTRODUCTION

This document has been prepared pursuant to the Conditional Approval Letter from the New Mexico Environment Department (NMED) dated January 24, 2000 and reports the results of the site investigation of the Groundhog Mine area (Figures 1 and 2), within the Hanover/Whitewater Creeks Investigation Unit (H/WCIU). This report was prepared by Golder Associates Inc. (Golder) under contract to Chino Mines Company (Chino). The purpose of the site characterization was to define the chemical nature and physical extent of mining-related materials at a level sufficient for Chino to evaluate remedial requirements and options for the site.

The Groundhog Mine falls under the jurisdiction of three regulatory programs. First, reclamation activities fall under the jurisdiction of the New Mexico Mining Act (NMMA) administered by the New Mexico Energy Mineral and Natural Resources Departments Mining and Minerals Division. A closeout plan is required under the NMMA rules, and the Groundhog Mine is included in the proposed closure/closeout plan for the Chino Mine. Second, the Groundhog Mine is not included in a discharge plan administered by the Groundwater Quality Bureau of the NMED. Consequently, the NMED and Chino have elected to address possible groundwater issues under the Chino Administrative Order on Consent (AOC) as part of the H/WCIUs. Finally, surface water runoff at the Groundhog Mine falls under the jurisdiction of Chino's Multi-Sector General permit under the National Pollutant Discharge Elimination System administered by Region VI of the U.S. Environmental Protection Agency (EPA).

The site investigation was completed as outlined in the Interim Remedial Action Groundhog Mine Stockpile, Site Investigation Workplan Hanover Whitewater Creeks Investigation Unit (Golder, 2000). The scope of the workplan included:

- Chemical characterization and evaluation of the lateral and vertical extent of stockpiles,
- Chemical characterization and surveying of roads and building foundations constructed of suspect materials,
- Geotechnical sampling along pipelines to address stability issues related to removal of materials adjacent to the pipelines,
- Sampling and inspection of the existing soil cover materials to address reclamation requirements, and

2. SITE DESCRIPTION

The Groundhog Mine is located in the valley of a north-flowing unnamed tributary to Whitewater Creek, north of Bayard Canyon. The underground mine operated from as early as 1869 (Lasky, 1936) until approximately 1978, producing primarily lead and zinc. Mineral deposits of the area are complex quartz-sulfide veins. The ore minerals are sulfides of copper, lead, and zinc, with minor silver and gold (Howard, 1967). The vein in the Groundhog area runs along the eastern edge of the valley, striking generally northeast. Prior to mining activities, the vein cropped out for approximately one-half mile and extended southwestward for an additional 3,000 feet or more along the east side of Bayard Canyon, where it was covered by Tertiary sedimentary rocks (Lasky, 1936). At the location of the San Jose Shaft, the vein outcrop formed a "prominent wall of jaspery quartz". The vein is now covered by stockpile material and a vegetated soil cover.

The unnamed tributary drains an area of approximately 100 acres. Chino constructed a headwall that tied into bedrock downgradient of most of the existing stockpiles (Figure 2) in 1996. The headwall was constructed with a gravity drain to a seepage collection system in Whitewater Creek. Diversion ditches were also excavated to divert upgradient surface water run-on around the site in 1996.

In August 1999, during a season of heavy rains, groundwater seeps were observed upgradient of the headwall. A pond of seepage and surface water behind the headwall eventually overflowed due to clogging of the discharge pipe with silt. The discharge, which was estimated at a volume of approximately 30,000 gallons, flowed through a drainage culvert, down a dry streambed and into Whitewater Creek. The discharge was stopped by installing a sump pump at the headwall and pumping the impounded water into a tanker truck for transfer to the process water system. The pump was left in place and connected to a process water line from Reservoir 16.

In June 2000, Chino installed a drainfield upgradient of the headwall and extended the capture area of the headwall with a subsurface hydraulic barrier across the rest of the drainage (Figure 3) The drainfield was excavated into bedrock and backfilled with pea gravel to capture seepage from the stockpiles. A perforated pipe runs the length of the drainfield at the base of the gravel. An impermeable liner anchored with riprap was placed on top of the gravel to separate clean surface water flow from seepage water. The subsurface hydraulic barrier comprises the buried headwall extended to the southwest by a gravel-filled trench with an impermeable liner on the downgradient trench wall. Seepage water collected in the drainfield and the subsurface extension of the headwall is currently being pumped from the drainfield into the Chino process water system.

Much of the surface water run-on is routed around the stockpiles by a series of upgradient diversion ditches constructed in 1996. Surface water runoff originating from the covered stockpiles is separated from seepage water by the impermeable liner over the drainfield and is allowed to discharge to Whitewater Creek.

The mine was last operated by Asarco but was previously owned by a number of companies. Chino obtained the property from Asarco in 1994. Prior to transferring the property, Asarco relocated several stockpiles from Bayard Canyon, combined several stockpiles associated with the Groundhog operations, and covered them with several inches of cover soil from nearby hillsides. Estimated stockpile locations prior to the investigation are shown on Figure 2. The area between Stockpiles G2 and G3 is the location of former mine operation facilities. Prior to the field investigation, the nature of the materials in the area, as well as the location of cuts and fills, was not known, although it was suspected that mine-related materials were present. These mine-related materials might include construction and/or demolition debris as well as waste rock. Consequently, the materials in this area are referred to as "suspect materials" (Figure 2).

Digital topography was developed from an aerial survey flown in 1999. No significant regrading has occurred in the area since the date of the aerial survey and it is believed that the digital topography accurately reflects current conditions. Figure 2 shows the general site layout with a 5-foot contour interval.

geotechnical analysis. Sample locations, identification numbers, depth intervals composited, and the sampling date are listed in Table 1. Sampling and analysis procedures are summarized below.

4.4.1 Sampling Procedures

Test pits excavated to less than 4 feet were sampled from the pit wall according to SOP 21 (Chino/SRK, 1997), "Sample Collection From Soil Borings, Excavations, and Hand Dug Pits". All sampling activities were documented according to SOP 2, "Field Logbook". The SOP (Chino/SRK, 1997) was modified for deeper pits to allow collection of discrete samples from the excavator bucket and compositing from these materials as described below.

Two types of samples were collected from the test pits:

- Composite samples. Composite samples were collected from distinct layers exhibiting a thickness of 2 feet or greater. One subsample was collected for each 2-foot interval. These subsamples were composited over each interval of the same material type.
- Grab Samples. A grab sample from the soil underlying the stockpiles or roads was collected at each test pit. In addition, five grab samples were collected from exploratory pits.

The project-specific sampling procedure developed for pits deeper than 4 feet was as follows:

- The operator collected a volume of soil with the bucket of the excavator backhoe from each 2-foot interval or distinct layer as appropriate, and emptied the bucket on the ground in the sampling area. The depth interval of the excavated material was confirmed by measuring the pit depth. The depth of the pit was generally within 2 inches of the desired depth.
- The field geologist inspected and logged the soil as described above.
- Approximately 1 gallon of the material was collected in a 3-gallon plastic bucket using a plastic bag as a liner, labeled with the depth interval, and held until the excavation was complete.

The final sample was a single grab sample of the soil underlying the mine-related materials. If no soil was encountered, weathered or fractured bedrock was sampled. After description, the sample of underlying materials was placed directly from the pile excavated at the pipelines (Figure 3) did not reveal the presence of stockpile material and it was assumed that the stockpile pinched out to the east of the pipeline.

5.1.2 Stockpile G2

Stockpile G2 does not appear to be associated with an adjacent shaft, and may be relocated material from Bayard Canyon. Two test pits were excavated into the stockpile (G2-1 and G2-2). The material within the stockpile was not stratified and appeared to be mixed or disturbed. For example, occasional lenses of clayey soil with roots would be mixed with mineralized clasts which were not weathered. In addition, the underlying soil and bedrock were not significantly weathered and did not contain visible secondary precipitates such as gypsum or jarosite. Figures 6 and 8 show the lateral extent and cross-section of Stockpile G2.

The soil cover ranged from 0 to 1.5 feet thick. The cover was thickest on the flat southeastern portion, and thinned on the northern slope.

The stockpile material was characterized by rounded tuff boulders and smaller clasts of granitic porphyry with feldspar phenocrysts and pyrite mineralization, small clasts and veins of chrysocolla, galena, and other associated minerals. Lenses of clay within the stockpile material had secondary iron oxide and copper hydroxide precipitates, but weathering rinds on clasts were generally thin. Underlying soil was mixed with relatively unweathered fractured bedrock approximately 2 feet thick in both test pits. Bedrock was gray siltstone that contained iron-rich quartz veins.

Exploratory Pit EP-12 north of G2 did not indicate the presence of mining-related materials. The southern and eastern extent were estimated based on the character of the surface (trees and artifacts). The western edge of the stockpile is buried beneath the new road and is assumed to extend to the edge of the pipeline corridor.

5.1.3 Stockpile G3 East

Stockpile G3 is associated with the San Jose Shaft and appears on historical maps and in literature published as early as the 1930s. One stockpile test pit (G3-1) and three exploratory test pits (EP-5 through 7) were excavated into the stockpile. Figures 7 and 9 show the lateral extent and cross-section of Stockpile G3.

The soil cover ranged from 0 to 1 foot thick, but did not sustain vegetation over the western half of the hillside, which had a hard crust.

5.2.1 Acid-Base Accounting

The ABA results are presented in Table 3 and on Figures 9A and 9B. Figures 10 through 15 provide graphical representations of the pertinent results.

In accordance with Price (1997), the following screening criteria are used to classify the samples in terms of their acid potential:

ARD Potential	Screening Criterion	Comments
Likely	Neutralizing Potential/Acid Potential (NP/AP) < 1	Likely ARD generating unless sulfide minerals are non-reactive
Possibly	1 < NP/AP < 2	Possibly ARD generating if NP is insufficiently reactive or is depleted at a rate faster than sulfides
Low	2 < NP/AP < 4	Not potentially ARD generating unless sulfides are preferentially exposed or extremely reactive in combination with insufficiently reactive NP
None	NP/AP > 4	Not acid generating

A fifth category follows an empirical rule of thumb. Materials with a pyrite sulfur content less than 0.3% and a paste pH greater than 5.5 generally are considered non-acid generating regardless of their NP/AP ratio. However, if the rock matrix consists entirely of base-poor minerals (e.g., quartz, muscovite), further evaluation is required (Price, 1997).

It should be noted that these criteria can only be used to identify the <u>potential</u> of a material to generate acid; the <u>likelihood</u> of acid generation and <u>rate</u> at which it occurs cannot be determined from ABA results alone. Long-term testing (e.g., humidity cell) and/or use of field testing/observations is generally required to address the latter issues.

Figure 10 shows the pyrite sulfur versus the total sulfur content. Correlation between sulfide and total sulfur is excellent, and pyrite sulfur on average accounts for approximately 50% of the total sulfur. On average, sulfate sulfur and residual sulfur represent approximately 45 and 5%, respectively. On Figure 11 (sulfate sulfur versus total sulfur), a similar relationship is observed, although at higher total sulfur values the trend starts to deviate. The good correlation between total and sulfate sulfur suggests that the sulfate is derived from the oxidation of sulfides, and is not caused by the presence of primary sulfates (e.g., gypsum, barite).

Figure 12 shows NP values versus AP values. Also included are the linear expressions of the ARD criteria advocated by Price (1997). Based on this classification alone, the majority

$$HFe(SO_4)_2.3H_2O + H_2O = H^+ + 2SO_4^{2-} + Fe^{3+} + 4H_2O \quad \textbf{(1)}$$

However, more importantly, formation of hydrous iron or aluminum oxides from dissolved iron and aluminum results in the generation of acidity as well. As a consequence, significant amounts of acidity can be generated when iron/aluminum-bearing sulfates dissolve and the released iron/aluminum subsequently precipitates. The dissolution of melanterite in Reaction 2 serves as an example of this process.

$$FeSO_4.7H_2O + 0.25O_2 = Fe(OH)_3 + 2H^+ + SO_4^{2-} + 4.5H_2O \quad \textbf{(2)}$$

A mineral particularly susceptible to this scenario is jarosite, which was observed as a precipitate in materials in the study area. Jarosite is only stable under very acidic conditions (pH < 3), so its presence is generally indicative of highly acidic (micro-) environments. Upon contact with solutions that are more alkaline (e.g., natural rainfall), jarosite dissolves, thereby releasing its hydrogen, when present. In addition, the precipitation of the liberated ferric iron as a hydroxide results in further generation of acidity (Reaction 3):

$$(H,K)Fe_3(SO_4)_2(OH)_6 + 3H_2O = (K^+,H^+) + 3Fe(OH)_3 + 2SO_4^{2-} + 3H^+ \quad \textbf{(3)}$$

The samples that contain stored acidity, therefore, constitute a potential reservoir of metals and acid that may be released intermittently. Although such samples do not impact water quality through sulfide oxidation, their periodic adverse effects on water quality, while not long-term, can be substantial in the short-term.

The lower right quadrant of Figure 15 represents samples that contain considerable pyrite sulfur and have a low paste pH. These samples have an obvious potential to generate acid. The samples in the upper right quadrant may or may not generate acid depending on their NP/AP ratios.

Based on these relationships, each sample was assigned one of the following classifications:

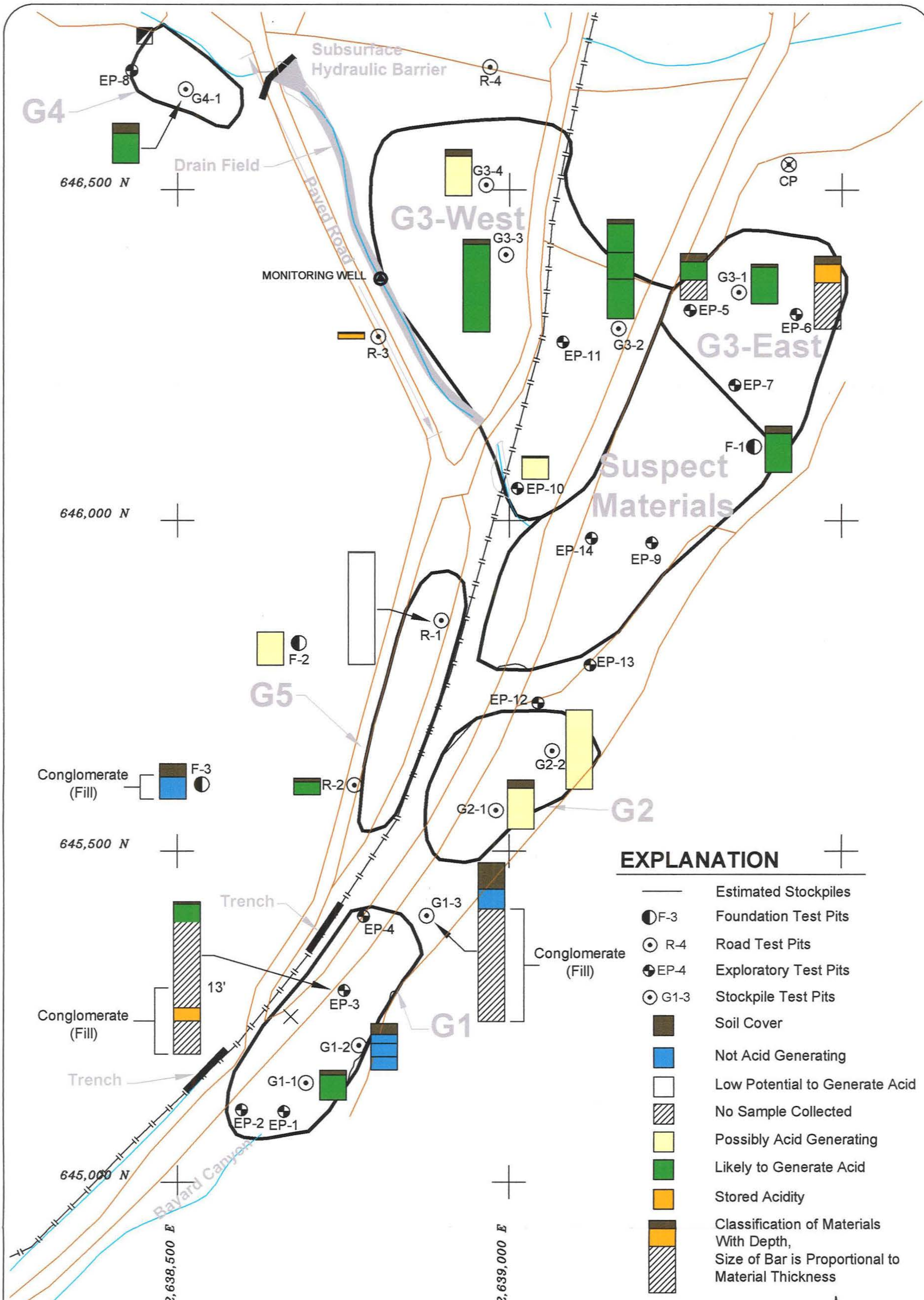
- Likely to generate acid – 12 samples
- Possibly generates acid – 8 samples
- Low potential to generate acid – 3 samples

For this reason, the volumes presented in Table 7 reflect the volume of material which would be practical to move if a removal action was selected as a remedy. The volume includes the soil cover, if it is thin or otherwise unsalvageable; the stockpile material; and the underlying soil and weathered or fractured bedrock where they are potential sources.

Figure 6 shows the estimated surface beneath each stockpile which represents material which is not impacted by acidity or a potential source of leachable metals. The ancestral topography is estimated on Figure 6 to aid in defining the target surface beneath each stockpile. However, the surface shown beneath each stockpile, and used for calculating volumes, is variably defined by either bedrock or the original surface, depending on the character of the materials. The volume estimate methods are summarized below for each stockpile. Calculation briefs are presented in Appendix E. Calculations were completed by digitizing the interpreted underlying surface and digitally subtracting the surface from the current topography. Figures 8 and 9 show the potential excavation surface in cross-section.

- Stockpile G1 - Volume estimates include the stockpile material below an elevation of 6,114 feet above mean sea level (the estimated base of the overlying neutral material) and the thin underlying soil/weathered bedrock (where present). The conglomerate material underlying the northern portion of the stockpile, which is not impacted, is not included in the volume. The underlying surface shown in Figure 6 would represent the bedrock and conglomerate. Approximately 30% of the stockpile is within the watershed of Bayard Canyon.
- Stockpile G2 - Volume estimates are given for both the stockpile material and the underlying soil. The underlying soil appears to be fairly unimpacted, but may contain some residual acidity. However, it is easily distinguished in the field and therefore could be left in place and reclaimed as a remedial option. Alternatively, it could be removed with the overlying stockpile to a different location as a second removal option. The volume excludes the soil cover on the southeastern portion of the stockpile.
- Stockpile G3 East - The volume includes the soil cover, stockpile material, and underlying soil/weathered bedrock.
- Stockpile G3 West - The volume includes stockpile material and underlying soil/weathered bedrock. While the upper interval and northern end of the stockpile are not as acidic as the rest of the stockpile, the change is gradational from a likely source to a possible or low potential source.

- Stockpile G4 - The volume includes the stockpile material only. The soil cover is salvageable and the underlying soil does not generate acid.



NOTE

1. The surface beneath the stockpiles may represent either the bedrock or the depth to the original ground surface, depending on the depth of acidic materials.

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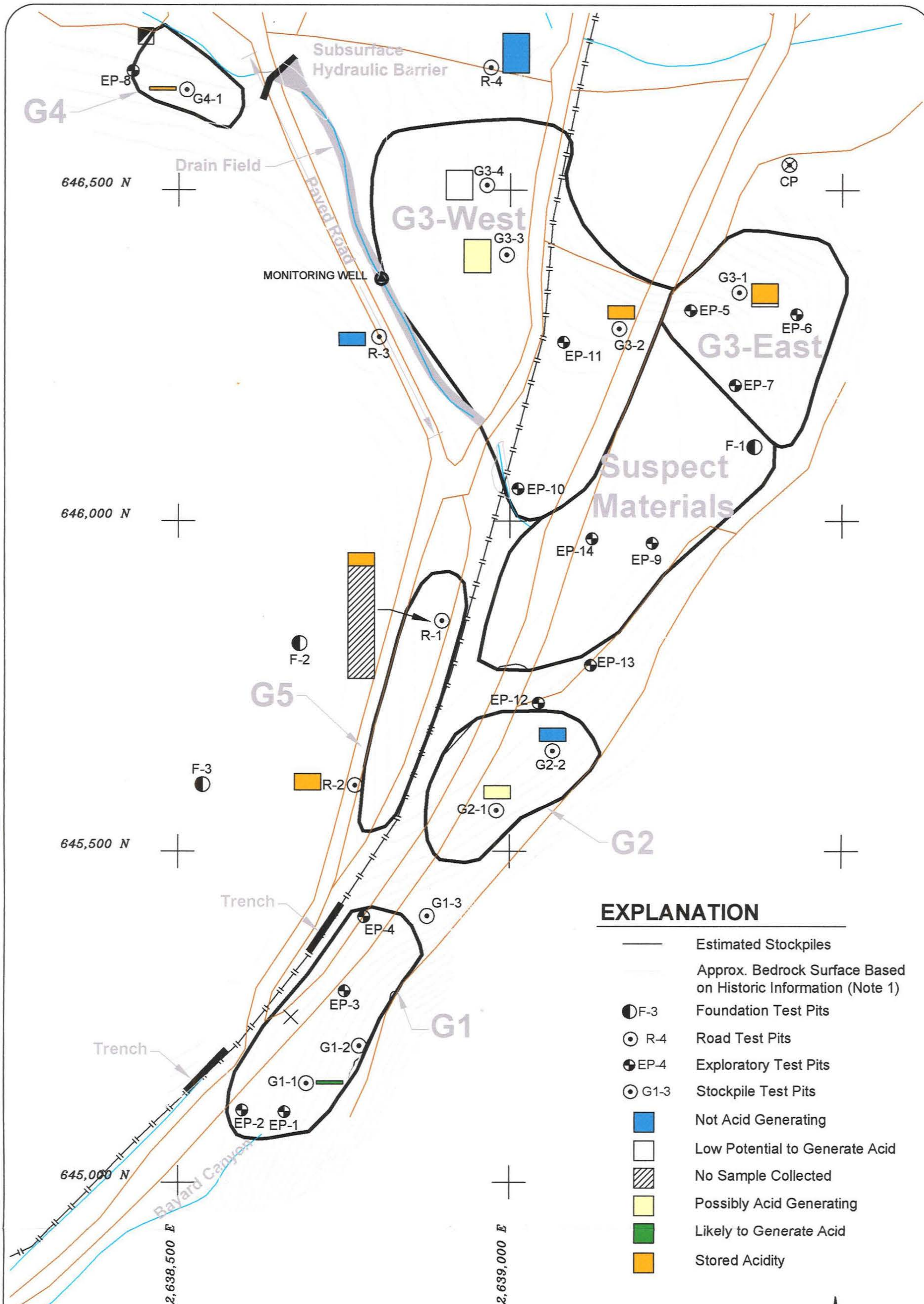
Golder Associates

Tucson, Arizona

FIGURE 9A

Acid-Base Accounting Classifications for Mine-Related Materials

PROJECT NO.	CLIENT	PROJECT	REVISION	DATE	SCALE
003-2562	Chino Mines Company	Groundhog Site Investigation	A	04/20/01	1"= 150'



NOTES

1. The surface beneath the stockpiles may represent either the bedrock or the depth to the original ground surface, depending on the depth of acidic materials.
2. The length o fthe bar is proportional to the thickness of underlying materials.

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Tucson, Arizona

FIGURE 9B

Acid-Base Accounting Classifications for Soils and Weathered Bedrock Underlying Mine-Related Materials

PROJECT NO.	CLIENT	PROJECT	REVISION	DATE	SCALE
003-2562	Chino Mines Company	Groundhog Site Investigation	A	04/20/01	1"= 150'